Visual Odometry for Autonomous Deep-Space Navigation Project

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Primary TA:

Start TRL: 4

End TRL: 5

Goal / Gap **Limit: 3 Sentences to 1 Paragraph**

Indicate the goal being addressed. Provide a brief statement about the capability need / knowledge gap, including a brief review of state of the art / knowledge in this area.

Autonomous rendezvous and docking (AR&D) is a critical need for manned spaceflight, especially in deep space where communication delays essentially leave crews on their own for critical operations like docking. Previously developed AR&D sensors have been large, heavy, power-hungry, and may still require further development (e.g. Flash LiDAR). Other approaches to vision-based navigation are not computationally efficient enough to operate quickly on slower, flight-like computers.

Approach / Innovation **Limit: 1 Paragraph to 2 Paragraphs**

Identify one or more key technical challenges and provide a brief overview of the technical approach / research plan including one or more key objective(s), milestone(s), or deliverable(s) for this year. Describe how this is different from or complimentary of other efforts in industry, academia, or government. Briefly state the next step(s) anticipated after this year's work.

The key technical challenge for visual odometry is to adapt it from the current terrestrial applications it was designed for to function in the harsh lighting conditions of space. This effort leveraged Draper Laboratory's considerable prior development and expertise, benefitting both parties. The algorithm Draper has created is unique from other pose estimation efforts as it has a comparatively small computational footprint (suitable for use onboard a spacecraft, unlike alternatives) and potentially offers accuracy and precision needed for docking. This presents a solution to the AR&D problem that only requires a camera, which is much smaller, lighter, and requires far less power than competing AR&D sensors.

Results / Knowledge Gained **Limit: 1 Paragraph to 2 Paragraphs**

Briefly describe the outcome and knowledge gained (this includes lessons learned). Insert or append any images or charts that add context to the results. Identify any funded follow on work.

We have demonstrated the algorithm's performance and ability to process 'flight-like' imagery formats with a 'flight-like' trajectory, positioning ourselves to easily process flight data from the upcoming 'ISS Selfie' activity and then compare the algorithm's quantified performance to the simulated imagery. This will bring visual odometry beyond TRL 5, proving its readiness to be demonstrated as part of an integrated system.

Once beyond TRL 5, visual odometry will be poised to be demonstrated as part of a system in an in-space demo where relative pose is critical, like Orion AR&D, ISS robotic operations, asteroid proximity operations, and more.

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Reports / Proposals

Style: List

*List any publications, new technology reports, pending patents, subsequent proposals, follow-on / spin-off work **selected** by another program, etc. that resulted from this activity.*

Title of Item	Type: Publication, NTR, Pending Patent, Solicitation Title, Program Sponsorship, or Other	Status: Confirmed or Submitted	Brief Description
Robotic Vision System	Proposal	Submitted	Use visual odometry to accelerate ISS robotic operations.
Visual Odometry Development for ISS Robotic Operations	Proposal	Submitted	Create a capability to provide exact SPDM offset from ORUs.

Technology Maturation Opportunities (Optional) **Limit: 1 Paragraph to 2 Paragraphs**

Beyond any follow-on / spin-off work or proposals identified above, suggest the next step STMD could help support to mature the technology. Consider what form the next activity might take: further research and development, commercial or academic involvement, orbital / suborbital flight testing, etc.

Recommended STMD Next Steps	Type further research and development, commercial or academic involvement, orbital / suborbital flight testing, etc.	Description
Tune algorithm based on on-orbit imagery	Further R&D	Further tune the system to get the best performance possible from the flight imagery and data
In-space demo	Orbital flight testing	Demonstrate system on-orbit, further increasing the TRL and heritage
Commercial solicitation	Commercial involvement	Advertise capability to those interested in AR&D to see if they can leverage the technology to enhance their capabilities

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Resources

List value of collaboration in $

Collaborator	Type (NASA, academia, etc.)	Est. Value of Resources (FTE, Hours, or $$)	Overview
Draper Labs	Nonprofit Lab	Leveraging $6 million in previous development	Provided algorithm development
ROBO	NASA	40 hours	Provided input, analysis, and eventual execution of 'ISS Selfie'
ER	NASA	0.1 FTE	Provided 'ISS Selfie' simulation and assisted arm motion development
EG	NASA	$50k	Provided (partially) matching funds